Tuning Fork tests

A review

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Authors

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Abstract

This article reviews the history of tuning fork tests, its current status as a clinical examination tool. All the commonly performed tuning fork tests are discussed in detail. The three commonly performed tuning fork tests include: Rinne test, weber test and Absolute bone conduction test.

Tuning fork tests

Introduction:

Right from 17th century[1]onwards it was established that humans perceive sound both via air conduction and bone conduction. Air conduction and bone conduction threshold measurements could differentiate middle ear from inner ear causes of deafness. This knowledge was also widely available those days. Since this differentiation had very little therapeutic value for otolaryngologists those days, little progress was made in this direction. Invention of tuning fork by John Shore in 1711 a trumpeter changed the whole scenario. Before this discovery musicians relied on wooden pitch pipes [2]to identify the frequencies. These wooden pitch pipes caused lots of errors due to temperature and humidity changes which could affect these wooden pipes. Clinical otologists started believing that they had a diagnostic tool that could differentiate middle ear deafness from inner ear ones.

The exact physics of tuning fork was studied by the German Physicist E.F.F. Chladini in Wittenburg during 1800. He analysed and reported the mode of vibration of tuning fork around its nodal points. He is considered to be the father of experimental acoustics.

Physicist Venturi from Modena Italy in 1802 proved that perception of direction of sound was due to the fact that one ear is hit by more intense sound than the other.

Advantages of tuning fork include:

1. It produces a pure tone

2. Vibrates real close to its fundamental frequency

3. Produces very little overtones

It was the Italian physician Capivacci in 1550 who suggested that extraneous sounds can be used to determine whether deafness is due to middle ear / inner ear causes. In 1827 Wheatstone a London based physicist investigated the mode of vibration of ear drum using a tuning fork. He concluded direction of sound is perceived by a maximally vibrating ear drum. Weber an anatomist from Leipzig Germany described the same phenomenon as Wheatstone. He attempted to prove that air borne sound was perceived by the vestibule and semicircular canals and bone conducted sounds by the cochlea.

It was E. Schmalz an otologist from Dresden Germany in 1845 [3]introduced the tuning fork test in otology which he later named as Weber in honor of Weber. He was the first to claim the diagnostic possibility of using a tuning fork. This achievement did not attract that much attention during his times.

It was later left to Tondroff [3] who stressed the importance of tuning fork as a diagnostic tool in the field of otology.

Tondroff by his classic studies offered the most detailed and complete explanation of the working mechanism of bone conduction hearing. Tondroff identified four major bone conduction components[4]:

1. Middle ear inertia

2. Middle ear compliance

3. Inner ear compression

4. Round window release

Commonly performed tuning fork tests [5]:

Tuning fork tests are performed in order to subjectively assess a person's hearing acuity. This test can in fact be performed by using tuning forks of the following frequencies (254 Hz, 512 Hz, and 1024 Hz). Frequencies below 254 Hz are better felt than heard and hence are not used. Sensitivity for frequencies above 1024 Hz is rather poor and hence is not used.

Prerequisites for an ideal tuning fork:

1. It should be made of a good alloy

2. It should vibrate at the specified frequency

3. It should be capable of maintaining the vibration for one full minute

4. It should not produce any overtones

Methodology of using tuning fork:

The tuning fork must be struck against a firm surface (rubber pad / elbow of the examiner). The fork should be struck at the junction of upper 1/3 and lower 2/3 of the fork. It is this area of the fork which is capable of maximum vibration.

The vibrating fork should be held parallel to the acoustic axis of the ear being tested.

Advantages of tuning fork tests:

1. Easy to perform

2. Can even be performed at bed side

3. Will give a rough estimate of the patient's hearing acuity

The following tests can be performed using a tuning fork:

1. Rinne test

2. Weber test

3. ABC test

4. Bing test

5. Politzer test

6. Bing Entotic test

7. Stenger's test

8. Gelle test

9. Chimani-Moos test

Rinne test:

Rinne's test: is a tuning fork test used to clinically test hearing deficiencies in patients. It is designed to compare air conduction with bone conduction thresholds. Under normal circumstances, air conduction is better than bone conduction.

Ideally 512 tuning fork is used. It should be struck against the elbow or knee of the patient to vibrate. While striking care must be taken that the strike is made at the junction of the upper 1/3 and lower 2/3 of the fork. This is the maximum vibratory area of the tuning fork. It should not be struck against metallic object because it can cause overtones. As soon as the fork starts to vibrate it is placed at the mastoid process of the patient. The patient is advised to signal when he stops hearing the sound. As soon as the patient signals that he is unable to hear the fork anymore the vibrating fork is transferred immediately just close to the external auditory canal and is held in such a way that the vibratory prongs vibrate parallel to the acoustic axis. In patients with normal hearing he should be able to hear the fork as soon as it is transferred to the front of the ear. This result is known as Positive Rinne test. (Air conduction is better than bone conduction). In case of conductive deafness the patient will not be able to hear the fork as soon as it is transferred to the front of the ear (Bone conduction is better than air conduction). This is known as negative Rinne. It occurs in conductive deafness. This test is performed in both the ears.

If the patient is suffering from profound unilateral deafness then the sound will still be heard through the opposite ear this condition leads to a false positive Rinne.

Use of Rinne test in quantifying conductive deafness:

Conductive deafness of more than 25 dB is indicated by negative Rinne with 512 Hz fork, while it is positive for 1024 Hz. If Rinne is negative for 256, 512 and 1024 Hz then conductive deafness should be greater than 40dB.

Weber test:

Is a tuning fork test (quick) used to assess hearing levels in an individual. This can easily detect unilateral conductive and unilateral sensorineural hearing loss. This test is name after Ernst Heinrich Weber (1795 – 1878). This test is ideally performed at a bone conduction level of 40 – 50 dB hearing threshold levels. Any increase in this level would lead to distortion.

Procedure:

Tuning forks used – 256 Hz / 512 Hz

Commonly used frequency is 512 Hz.

A vibrating fork is placed over the forehead / vertex / chin of the patient. The patient should be

instructed to indicate which ear hears the sound better. In normal ear and in bilateral equally deaf ears the sound will be heard in the mid line. This test is very sensitive in identifying unilateral deafness. It can pick out even a 5 dB difference between the ears.

Theory:

A patient with a unilateral (one-sided) conductive hearing loss would hear the tuning fork loudest in the affected ear. This is because the conduction problem masks the ambient noise of the room, whilst the well-functioning inner ear picks the sound up via the bones of the skull causing it to be perceived as a louder sound than in the unaffected ear.

Inadequacies:

This test is most useful in individuals with hearing that is different between the two ears. It cannot confirm normal hearing because it does not measure sound sensitivity in a quantitative manner. Hearing defects affecting both ears equally, as in Presbycusis will produce an apparently normal test result.

Absolute Bone conduction test:

This test is performed to identify sensorineural hearing loss. In this test the hearing level of the patient is compared to that of the examiner. The examiner's hearing is assumed to be normal. In this test the vibrating fork is placed over the mastoid process of the patient after occluding the external auditory canal. As soon as the patient indicates that he is unable to hear the sound anymore, the fork is transferred to the mastoid process of the examiner after occluding the external canal. In cases of normal hearing the examiner must not be able to hear the fork, but in cases of sensori neural hearing loss the examiner will be able to hear the sound, then the test is interpreted as ABC reduced. It is not reduced in cases with normal hearing.

Bing test:

This is actually a modification of weber's test. The vibrating fork is placed over the mastoid process and when it ceases to be heard the examiner's finger is used to occlude the external auditory canal. In normal individuals the sound will be heard again. This is because by occluding the external auditory canal the examiner is preventing sound from escaping via the external canal. The external auditory canal acts as a resonating chamber. If the vibrating fork is not heard again after the external canal is occluded then it is construed that the middle ear conduction is the cause for deafness. In patients with pronounced deafness if the vibrating fork is heard after occlusion of external canal then deafness is construed to be due to labyrinthine causes.

Politzer test:

In this test the vibrating fork is held in front of open mouth and the patient is asked to swallow. If the Eustachian tubes are patulous then sound will be intensified during swallowing. If only one tube is patulous then sound will be accentuated only in that ear. Sometimes normal persons too may not hear the vibrating fork.

Bing Entotic test:

Hypothetically this test is supposed to differentiate between deafness due to ankylosis of foot plate of stapes from that of conditions interfering with mobility of other ossicles. This test is actually of historic value only. Eustachian catheter is passed and to one of its ends is attached a speaking tube. If the patient is able to hear the fork better via this tube than that from the external auditory canal then

middle ear ossicles other than foot plate of stapes is supposed to be at fault.

Stenger's test:

This test is performed to identify feigned hearing loss and malingering. This test is based on the auditory phenomenon known as "Stenger's principle". This principle states that when two similar sounds are presented to both ears only the louder of the two would be heard. Patients usually are not aware of this phenomenon. When two similar tuning forks of same frequencies are made to vibrate and held simultaneously in the acoustic axis of both ears only the louder fork will be heard. Loudness of vibrating fork can be adjusted by adjusting the distance of the fork from the external canal. Usually the vibrating fork is held closer to the allegedly deaf ear of the patient. The patient will not acknowledge hearing in that ear. According to Stenger's principle he should be able to hear the louder fork. If the hearing loss in worse ear is genuine, patient will respond to the signal presented to the better ear. This is known as negative Stenger's test. Feigning patient will not acknowledge hearing when louder sound is presented to the worse ear. This is known as positive Stenger's test.

Gelle test:

In this test, the air pressure in the external canal is varied using a Siegle's speculum. The vibrating fork is held in contact with the mastoid process. In normal individuals and in those with sensorineural hearing loss, increased pressure in the external meatus causes a decrease in the loudness of the bone conducted sound. In stapes fixation no alteration in the hearing threshold is evident.

Chimani-Moos test:

This is actually a modification of Weber test. When the vibrating fork is placed on the vertex, the patient indicates that he hears it in the good ear and not in the deaf ear. The meatus of the good ear is then occluded. A genuine deaf patient will still be able to lateralize the sound to the good ear, where as a malingerer will deny hearing the sound at all.

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References

1. History of tuning fork II Feldmann H Laryngorhinootologie. 1997 May;76(5):318-26.
2. http://www.hps.cam.ac.uk/whipple/explore/acoustics/historicalnotes/
3. Tschiassny K. Tuning fork tests. A historical review. Ann Otol Rhinol Laryngol. 1946; 55:433-430.
4. Khanna S, Tonndorf J, Queller J. Mechanical parameters of hearing by bone conduction. J Acoust Soc Am. 1976;60:139-154.
5. https://sites.google.com/site/drtbalusotolaryngology/otology/tuning-fork-tests